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Field Comparisons of Irrigation Scheduling by Neutron Probe and a Computerized Water Balance

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A 5-year (1977-1981) experiment was conducted at the Irrigation Experiment Field at Scandia to determine the effectiveness of irrigation as it was applied at various soil-water conditions.

The experiment was conducted on a Crete silty clay loam (fine, montmorillonitic, mesic, typic, Arguestall). Corn (Zea mays L.) was planted in 30-inch rows at a seeding rate of 27,000 seeds per acre (Table 1). A randomized complete block with four replications was used in plots of 18 by 150 feet. Fertilizer, herbicide, and insecticide applications were uniform for all treatments. Standard agronomic practices were followed.

Table 1. Planting, tasseling, and harvesting dates for 1977-1981.

Year	Planting Date	Tasseling Date	Harvest Date	Hybrid
1977	April 25	July 1	Sept. 27	Pioneer 3184
1978	April 27	July 1	Sept. 22	Pioneer 3184
1979	April 26	July 17	Oct. 4	Pioneer 3194
1980	April 25	July 4	Sept. 24	Cargill 967
1981	April 24	July 9	Sept. 21	Cargill 967

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AGRICULTURAL EXPERIMENT STATION
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Four treatments were evaluated for yield response to water application: T1—no irrigation; T2—irrigated at 50% depletion in the upper 36-inch profile as estimated with neutron probe; T3—irrigated at 50% depletion in the upper 36-inch profile as estimated with computerized water balance (Rosenthal et al. 1977); T4—irrigated at 35% depletion until silking, thereafter at 65% depletion in the upper 36-inch profile as estimated with a computerized water balance. Plots were furrow irrigated with each irrigation applying about 3 inches of water (Table 2).

Neutron tubes were installed in each replication of all treatments to a depth of 6 feet. Measurements of soil moisture were made periodically, (usually on a weekly basis) to a depth of 36 inches. The upper limit to extractable soil water is 12.5 inches in the 36-inch profile. Leaf area measurements and growth stages were determined each week on all treatments.

Each week the daily solar radiation, maximum temperature, minimum temperature and precipitation amounts for the previous week are telephoned from the Scandia field to Kansas State University at Manhattan. The computerized water balance model is run using observed and simulated weather data (assuming no rainfall) to forecast the next irrigation cycle. If rainfall occurs before the irrigation, the model is rerun to forecast a new irrigation date.

The computerized model estimates the soil moisture from a water balance. Potential evapotranspiration (PET) is estimated from the Priestley-Taylor equation:

$$PET = 1.35\,[s/(s + \gamma)]\,Rn$$

where γ is the psychrometric constant; s is the slope of the saturation vapor pressure curve; and Rn is the 24-hour net radiation. (s and γ can be obtained from meteorological tables.) The net radiation is estimated by:

$$Rn = aRs + b$$

where a and b are regression parameters and Rs is the solar radiation.

The actual evapotranspiration is obtained by summing the evaporation rate from the soil surface and transpiration rate from the plant surfaces. These two components of evapotranspiration are estimated from PET and the leaf area index. The leaf area index is the ratio of leaf area to soil area. A leaf area index of one would be obtained if all the leaves in the field were laid flat and just cover the field area. The leaf area is obtained by actually measuring the leaf area of plants, weighing the leaves, or using a model to simulate the growth of leaves.

Each irrigation consisted of 3 to 4 inches of applied water. Because runoff was not measured, we can only estimate the effective irrigation amount. However, past experience and frequent soil moisture measurements provide reasonable estimates of irrigation. In general, T2 and T3 treatments were given the same number of irrigations while there were additional irrigations of T4 during 1979 and 1980.

The grain yields were significantly affected by irrigation (Table 3). However, there was little difference among the irrigation treatments. Therefore, it appears that a computer scheduling technique could be implemented by an individual irrigator, commercial consulting company, or extension personnel.

It is also apparent that for this particular location, the early irrigation near tasseling is very important to grain yields.

*Table 2. Irrigation dates for T1, T2, T3, and T4 for 1977-81.**

Year	T1	T2	T3	T4
1977	----	July 5, 18	July 9, 25	July 5, 25
1978	----	July 18	July 12	July 7, 11
1979	----	July 27, Aug. 8	July 31, Aug. 31	June 25, July 27, Aug. 10
1980	----	June 30, July 14, 29	June 30, July 15 25, Aug. 6	June 27, July 4, 13, 24, Aug. 4, 14
1981	----	June 24, July 14	July 2, 17	July 1, 13

*T1 = no irrigation; T2 = 50% with neutron probe; T3 = 50% with computer; and T4 = 35%/65% computer.

Table 3. Corn grain yields (15.5%) moisture for T1, T2, T3, and T4 for 1977-1981 (bu/A).

	1977*	1978	1979	1980	1981
T1	26.3c	129.8b	116.9b	1.5b	127.0b
T2	162.0a	158.3a	143.1a	129.7a	179.7a
T3	108.6b	163.0a	144.3a	128.1a	159.2a
T4	142.2a	145.7ab	139.4a	129.3a	162.4a

*Yields followed by different letters within a column differ significantly (0.05) by Duncan's Multiple Range Test.